STATIONARY BATTERY PERFORMANCE PROFILING AND DATA INTEGRATION

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ABSTRACT

Accurate data collection is critical to establishing baselines and trending battery function variables. System reliability at a reasonable cost depends on the quality of this information. While manufacturer and industry standards are available for guidance, neither, due to frailties of manufacturing or component consistency, is able to provide the bead on service life estimation that benchmark data can provide. Delivery of critical service as well as routine maintenance functions can extend battery life and reliability when delivered in accordance with individual cell and string characteristics and requirements using data that refine manufacturer and industry-based statistics. These benefits are dependent on consistent and well-organized data that reveal unique performance profiles.

INTRODUCTION

This paper covers a brief review of conventional methods of battery data collection. We will then explore refinements in data collection methods, analysis, trending, training and the benefits of using an omnipresent data platform. Content is based on case studies that have been conducted over the past two and half years that highlight the need and benefits of enhanced tracking of individual cell, string, and plant parameters rather than relying on industry or manufacturer based guidelines. Additionally, through case studies we will illustrate how data currently being collected is not meeting levels of accuracy needed to obtain critical information in properly evaluating battery plant performance.

STATIONARY BATTERY APPLICATION

The growth in UPS, telecommunication, and more recently CATV industries has brought with it a huge demand for stationary batteries. Each system, of which these batteries are an element, plays a critical role in the technical health and financial viability of the businesses they support. In years past, the battery and associated power supply equipment were installed in areas where facility maintenance people kept round the clock vigils ensuring proper maintenance routines were followed and reliability issues could be addressed instantly. With the streamlining of personnel and operations over the past decade, the same technical oversight by the plant and facilities engineering staff is not available in today's environment.

Advancements of microelectronics have led to significant changes in the size of the supporting power systems that use batteries for back up. In many cases, existing telecom and other plants expanded capability and this squeezed out the space allotment for batteries. This resulted in equipment being taken out of the watchful eye of the in-house maintenance group and being located in obscure spots in computer rooms, storage rooms, overhead mezzanine decks and closets. Additionally, specialized applications are housed in environmental enclosures that were developed to allow systems to be placed on utility poles, at ground level, and below-grade locations. The latter applications, being present primarily in the cellular, fiber-optic communication, and CATV industries, have led to creation of thousands of environmentally safe enclosures.

BATTERY INDUSTRY GROWTH

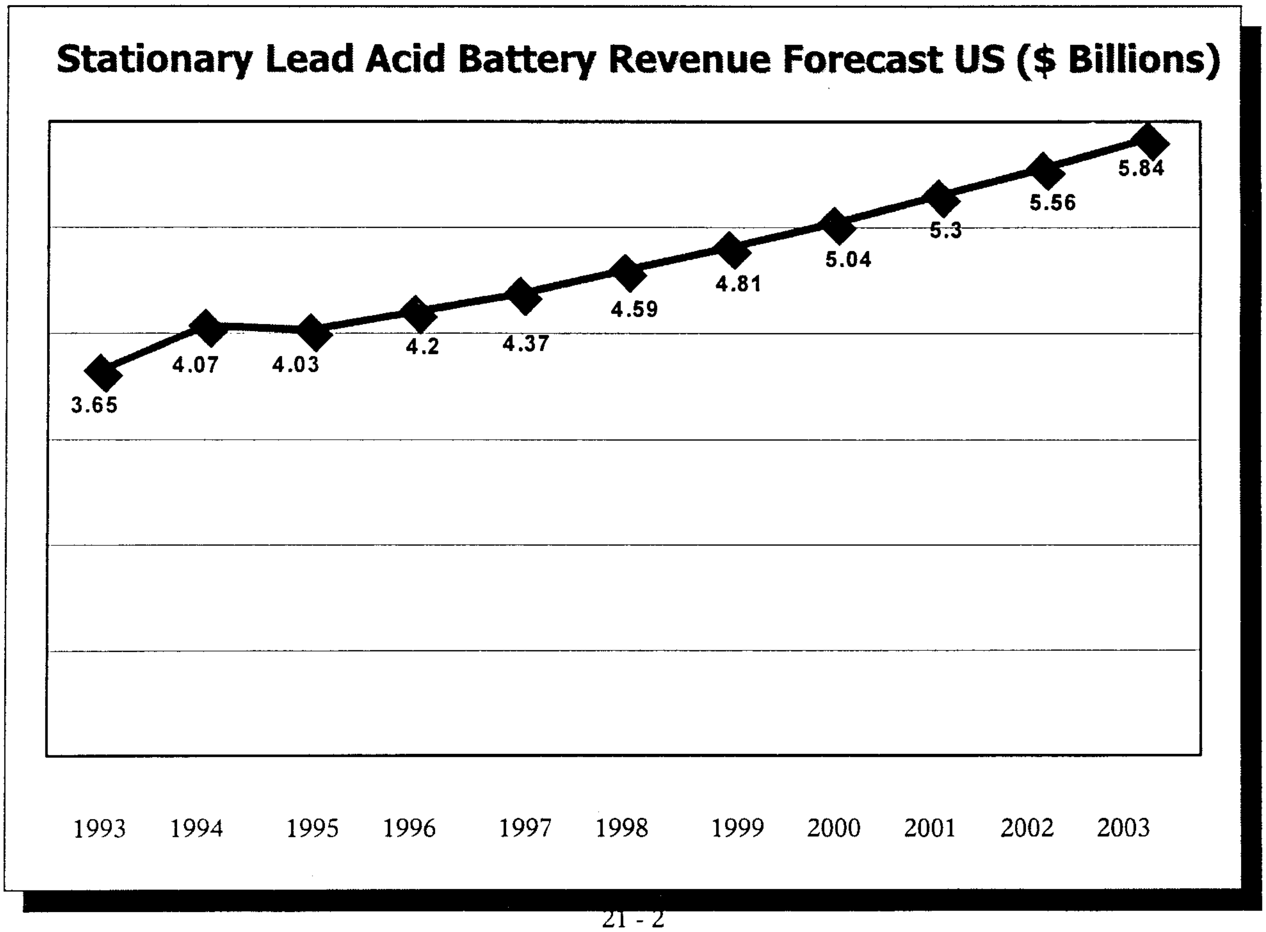
It is first important to understand the magnitude of the battery industry both now and where it is projected to be over the next three years. In the commercial sector, which uses batteries as both a primary and back-up power source, the lead acid battery market in the US alone was $4.59 billion in 1998. It is expected to reach $5.84 billion by 2003. Total battery sales globally, in all categories, are $60 billion a year and expected to grow at double-digit rates through 2006. The role data management will play during the next few years will be monumental. The need for new, cost effective, low overhead management tools will be paramount. Present data management and analysis processes will not be effective in the future as seen by the forecasted industry growth. The growth from 1993 to 1997 was 16%; from 1997 to 2003 the growth is forecasted to be over 25%. Some indicators have pegged growth at even a greater increase as new markets mature.

Drivers Behind the Growth in Battery Requirements

The long distance telephone market is approximately $100 billion per year. There are the seven (plus or minus) Regional Bell Operating Companies which generate billions per year. This market is growing about 5-6% per year domestically, but faster for international.

The fastest growth sector in telecommunications is the Internet. There are three upper level Internet providers in Fairfax County, Virginia alone: UUNET, PSINet and AOL. In addition, US-wide there are over 8,500 Internet Service Providers– as of yesterday. This segment of the industry has traffic growing by 50-100% per year. Network Solutions, Inc., the domain name registrar, registered 1.8 million NEW names in the month of December 1999 alone. The total number of domain names to date is over 60 million.

The latest figures indicate that 53% of US households are on the Internet at dial up speeds. It is projected that by 2008 approximately 80% of households will be online; at this level the US would be considered to be covered. With the current pace of DSL development and rollout, not only will the pace quicken, but the speeds available to small office, home office and households will rise rapidly. All these factors will increase the requirements for hosting sites, content and content access, and overall facility upgrades and expansions.



TRADITIONAL PRACTICES IN DATA COLLECTION AND ANALYSIS

Regardless of equipment location or housing characteristics, the fact remains that ongoing data collection is a requirement for performing recommended maintenance routines. Given the prevalence and desirability of applying VRLA (Valve Regulated Lead Acid) Batteries in the computer age industrial landscape, inspection schedules are changing. With the VRLA battery, inspection is usually quarterly and perhaps as little as once per year. This contrasts with flood battery inspection schedules, which typically map out monthly inspections, which at a minimum insure proper water levels. This increasing prevalence of the VRLA battery creates the imperative to get the most out of data that are collected to pinpoint in time unit- and set-specific rates of degradation of performance indicators like voltage, internal ohmic values and load testing.

There are three traditional forms of data collection and analysis employed in the industry today: 1) Manual data logging, 2) portable electronic test instrumentation with data collection, storage, and print out functions, and 3) fixed mounted battery monitoring systems.

•Manual logging is a function performed by trained technicians recording results of various onsite inspection routines. Simple non-parametric measurements are taken and recorded. When a monitor is in use, visual inspection of cases and plates may precede routine corrective services to manage corrosion, water levels, and mechanical integrity of the container. Problems with this form of data capture abound. Handwritten paper based information is often sketchy, illegible, subject to being misplaced, and the technician is inadvertently given a role as gatekeeper. The most serious drawback to manual logging is once the records are filed, they probably will not be looked at again. In addition there can be no comparison of data to previous readings.

•Portable electronic test instruments are all-in-one testers. They function very effectively to guide the technician in the capture and storage of information such as voltage, inter-cell connector resistance, internal ohmic values, and hydrometer measurements. The instruments incorporate this information into a file that can be electronically delivered to field supervision and corporate management where it can be used for performance analysis, scheduling, and report generation. These devices have greatly improved the accuracy of data collected by the technician and improved field force efficiency.

•Monitoring packages are cost-effective only at large battery facilities where they collect data continuously. The data that is gathered resides in isolation adjacent to the plant being monitored and has to be channeled into a non-integral database if it is to be used effectively to manage an entire system. Some OEMs hope to expand the application of monitoring packages by lowering the cost of these expensive systems using more rudimentary monitoring practices. These may provide simple general alarms, but again, the information is isolated and requires integration into a database to get full value.

INFORMATION TECHNOLOGY AWARENESS

Both information technology and outsourcing are playing precedent-breaking roles in large organizations. Both are influencing the battery industry, yet few management tools are available to industries such as the telecommunications industry which is increasingly relying on a number of independent firms that make up their battery service infrastructure. The independent contractors that make up the battery service infrastructure may not be oriented to using or offering advanced information management systems. This may be an issue end users themselves have to press when developing RFPs and contracting for services.

Reliability and Cost Savings

Benefits in these areas are available beyond those offered by traditional reporting methods. Current methods of reporting using handwritten reports can only provide a snapshot of the battery at the moment the technician is onsite. Automated data collection from continual, isolated onsite monitoring systems can provide voluminous amounts of information; however it is only valuable to that particular plant and only if the data is readily available with easy-to-read recommended action. The key to unlocking value in the data collected rests in organizing performance measures to reveal the unique profile of each battery cell, string, and plant across the entire network. The net result can result in JIT replacement of individual units or strings without premature replacement or sacrificing reliability to achieve maximum usable life of the battery.

Training

When battery plants were under the control of internal maintenance crews, training of personnel and to some extent consistent maintenance routines were ongoing. Personnel were trained in standard test practices. With services being outsourced, test requirements are typically specified in the bid proposal. What is not included is certification of training for the technician performing the work. The actual proficiency of the personnel performing the work can vary greatly. Proper training could be one of the solutions to achieving an optimum level of service and thus achieving consistent data collection using outsourced service providers. The challenge is to have training which is again standardized for a given application or industry and easily delivered to the service provider with the contract award. Again technology plays a key role in this area.

Fault and Repair Tracking

The ability to catalog faults and repairs is key to the reliability and integrity of the battery plant. Handwritten reports, which are delivered to the end user with repair actions, are handled in many different ways. In many cases it is the service provider and their individual organization's ability to throughput the reported action items and effectively follow-up on open issues. Manpower and workload variables will greatly affect the quality of this process even with the best intent. Additionally from the standpoint of a network, which can span the United States or globe, it is equally important to have the ability to catalog repairs and/or replacement of batteries to determine what potential facility or misapplication may be looming. Also important is to have the ability to find long range solutions to effect reliability and longevity.

Preventative Maintenance Scheduling

Network manager's struggle with managing a myriad of subcontractors and quantifying, on a periodic basis, the performance of the service provider in accomplishing the required number of visits. This results in either the facility manager spending too much time managing a process and/or contract compliance left in the hands of the vendor. While vendors have been relatively diligent in scheduling services it remains a coin toss. Additionally, when all is working well, an inordinate amount of time is spent coordinating the vendor and facility personnel setting the time and date. In some cases, for various reasons, PM dates are pushed out resulting in an excessive amount of time between services exceeding the recommended interval. Often PMs are bunched up at the end of the year to meet contract requirements. Ultimately it is the facility that sets the date and time for service windows. Optimally the service window should be established well in advance to allow service personnel adequate scheduling time. Also, when dealing with multi-facility networks, schedules for each facility should be on a global platform reducing network conflicts.

Continuity of Data

Using a variety of subcontractors and internal personnel makes uniform data collection very challenging. Well-organized cell, string and plant specific benchmark and trend information improve accuracy of end of life estimates that result in improved reliability and cost control. Well-organized information of this type also can serve as feedback to manufacturers to address quality control and warranty issues. Regardless of the means by which data are gathered, battery plant management is optimized if data is benchmarked against performance profiles unique to each array rather than against non-specific industry or manufacturer estimates. Through this unique performance profiling, limits can be established by the user that are sensitive to operational mandates and automatically alert field supervision of critical changes and the need to act.

Battery Disposal

EPA requirements relative to spent batteries are a major consideration. An article published by the EPA in 1997 covering hazmat in "business" classified buildings throughout the US, which excluded telecoms, manufacturers and utilities, stated there were well over 100 million gallons of sulfuric battery acid and 100,000 tons of battery lead in use. Adding industries that were not included and adding growth projections for battery disposal, especially for large end users, battery disposal will be a major concern. A data management system should have the capability of identifying the drop point of spent batteries in the event of an audit. Current EPA regulations require specific tracking of batteries to the recycling center. The recipient of the spent battery, which in most cases is a subcontractor, is required to maintain these records. The omnipresent data platform allows this kind of information to be logged in by a subcontractor or internal personnel.

Hazardous Material Information

Companies are being required to capture battery information in a central repository to be able to respond to EPA requirements and other local agencies. For instance, MCIW captures the manufacturer, model number, electrolyte volume, electrolyte mass, acid mass, acid percentage of electrolyte mass and battery type. This information usually requires significant manpower to gather if performed several times over the course of a year. A web-based repository would make this data instantly available.

FIELD EXPERIENCE WITH PERFORMANCE PROFILING

Through cooperation with the LDI BatteryNet™ data management system, a two and a half year snapshot of battery data revealed an alarming disparity in information. Data collected in the early part of the study shows wide variances between service providers for like service intervals. Additionally, data over the same period uncovered differences in trends. Information collected during maintenance routines in the latter part of the study was compared to early data, revealing a major improvement in consistency and detail of information. The significance of this demonstrates a trend toward increased quality of information which appears to be synonymous with service providers integrating advanced electronic battery testing devices, such as those supplied by Albér, Biddle and Midtronics as standard test equipment in the maintenance routine. It is noteworthy to point out the importance of having data collection online regardless of the service provider. The availability of state-of-the-art management systems and training tools are the driving force behind more accurate data collection. The end user/facility manager now has the means available to achieve optimum data collection, trending and analysis. It is important to point out the responsibility of the end user/facility manager to ensure the consistent use of the same test equipment and information reporting system by the service provider.

RECOMMENDATIONS

Instances of processing equipment being added, without consideration of HVAC and temperature sensitive equipment, will continue grow without awareness of the impact to other equipment. UPS and battery plants will exceed the design parameter and a system with an intended 15-minute backup will degrade as low as 3-4 minutes or no backup at all.
When a UPS is designed into a facility the UPS is typically sized at about 75 to 80 percent capacity and the battery is sized accordingly to support the load between 12 –18 minutes, average being 15 minutes. Added load on the UPS lowers the original design back-up time of the battery. The added temperature shortens the life of the battery. To avert damaging consequences and reduce facility downtime certain fundamental practices should be in place:

Recommendations

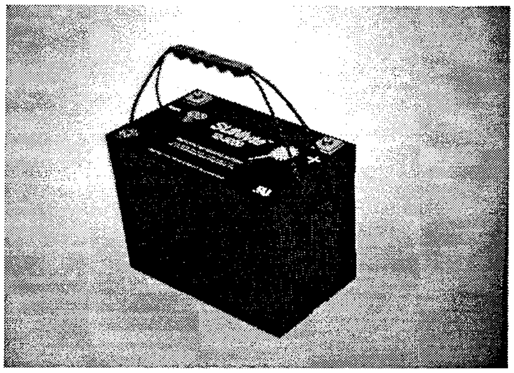
1. Data capture equipment should be standardized. This should be done across manufacturers using third party standards such as those offered by IEEE.
2. Data capture procedures should be standardized for various measurements. Those being measurements which are most critical and offer the most value for determining failures.
3. Written procedures should be posted at every site along with other relevant documentation, such as Material Safety Data Sheets (MSDS)
4. Standard procedures should be agreed upon by battery service companies, independent agencies, and consulting experts.
5. Technicians should be trained to be consistent with data capture procedures across the entire organization. This can be achieved through certification confirming a minimum knowledge regarding battery fundamentals, chemistry, electronics, and quality assurance procedures.
6. Calibration of test equipment should be performed on a regular basis by a certified calibration firm to NIST standards.

CONCLUSION

Whichever convention of data collection is used, end-users, service providers and manufacturers alike have everything to gain through a consistent, well-defined strategy for data collection, data management and technician training. This improved calibration of service could effectively reduce system redundancy, reduce investment over the life of the battery plant, and improve reliability. Rapid changes in information technology and business practices have created the opportunity and need for development of information management systems to integrate data from multiple platforms. BatteryNet™ and Knowdev on-line training are just examples of products available to the industry to meet the demands of the future. As numerous battery service providers are contracted to provide service to a large outsourcing organization, the need for information integration will grow. Service contract managers at these organizations need to consider how they are covering this issue in their RFPs and to implement processes that address the areas covered in this paper.

A Batteries (Sealed) Produced in KnowDev

Valve-Regulated Lead-Acid or VRLA batteries have been available since the early 1980's and offer several advantages over the conventional flooded electrolyte lead-acid battery design. VRLA batteries operate on an "Oxygen Cycle" principle in which the oxygen gas generated during charge at the positive electrode is reacted (or recombined) at the negative electrode with the hydrogen, thus preventing any water from being lost from the battery and eliminating any gasses from being vented.



VRLA batteries are constructed in such a way as to allow the gasses generated within the battery to readily diffuse between the plates in the battery and to permit the '"Oxygen Cycle" to be established. This is done by immobilizing the electrolyte solution in either a gelled form or totally absorbing the electrolyte in a glass mat (AGM) material. The immobilized electrolyte provides paths through which the oxygen gas generated at the positive electrode can diffuse to the negative plate and be available for recombination.

VRLA batteries provide a battery system design which requires less user maintenance, is spill proof and vents no hazardous gasses under normal operating conditions. VRLA batteries typically take up less floor space than a conventional flooded electrolyte battery of the same ampere-hour capacity, and because of their unique packaging, allow battery systems to be installed stacked one atop another and in the same environment as the electrical equipment they are powering.

In general the materials used in the manufacture of VRLA batteries are similar to those described for flooded electrolyte designs with the following exceptions.

The composition of the positive grid material is more critical in VRLA batteries than in conventional flooded battery designs. This is because certain additives to the positive and negative grid alloys can effect the efficiency of the battery's "Oxygen Cycle"

Most VRLA batteries are made using a lead-calcium or lead-tin alloy positive grid. These alloys have low gassing characteristics which are needed in a VRLA design, but also limit operation of the battery as to the number of shallow discharge cycles. As such , these batteries are restricted to standby applications where the quality of incoming power is highly reliable.

One notable exception is a VRLA battery (ABSOLYTE) manufactured by GNB Technologies which utilizes a proprietary MFX alloy in its positive grid. This patented low antimony alloy provides all of the characteristics of other VRLA battery designs but it allows the battery to be repetitively deeply discharged without loss of capacity or performance. This GNB battery has been demonstrated to deliver 1200 cycles to an 80% depth of discharge, and accelerated float life testing has projected a 20-year lifetime in most standby applications. The ability of this battery to provide this number of cycles demonstrates its robustness and tolerance to abusive operation conditions. The greater the number of cycles, the more reliable the service the battery can provide even under harsh operation conditions in areas with unreliable power.

As in a conventional flooded lead-acid battery, the electrolyte in a VRLA battery is a solution of sulfuric acid and water. However, in a VRLA design this electrolyte solution is 'immobilized". That is, the electrolyte is fixed in place either by a gelling technique or by absorbing the liquid in an absorbent glass mat (AGM) material so that oxygen gas can readily diffuse from the positive plate to the negative plate and establish an 'Oxygen Cycle".

The gelling technique solidifies the electrolyte solution by mixing the sulfuric acid with fumed silica (typically). Although this is a low cost approach, gelling the electrolyte increases the battery's electrical resistance and reduces its ionic conductivity, both of which reduce the performance capabilities of the battery. This effect is particularly evident in applications where the battery is discharged at higher currents or where a high operating voltage is required. Because of its higher internal resistance, gelled batteries typically generate greater amounts of internal heat which is detrimental to the battery's useful life.

The AGM approach has been widely accepted as the better method. Here, the liquid sulfuric acid solution is retained in a highly absorbent porous fiberglass material. Because this material is not completely saturated with the liquid electrolyte, it provides a uniform series of gas paths through which gasses can pass. This approach does not increase the battery's resistance and allows for a consistent and uniform dispersion of the electrolyte throughout the battery. Furthermore, because of the strong "wicking" capabilities of this material, it is possible to operate the battery in virtually any orientation without fear of electrolyte spillage.

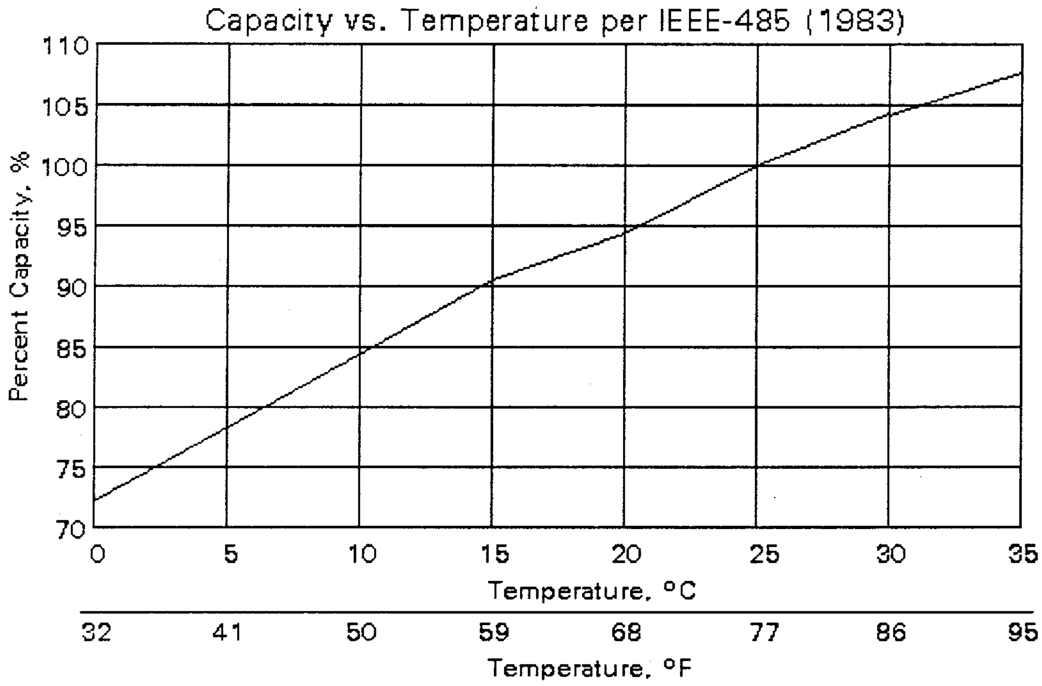
The container for a VRLA battery design has some special requirements. In addition to being resistant to chemical attack by sulfuric acid, the container material must have a low water vapor and oxygen gas transmission rate. That is, the material must be able to prevent water and/or oxygen from diffusing right through the plastic which over time could cause the VRLA battery to dry-out. Furthermore, the plastic material's thermal characteristics must be considered and the overall battery module design must provide for a high degree of thermal conductivity to remove heat from within the battery to an outer surface.

One material which is used for the battery container is polypropylene. It has very low water vapor and oxygen gas transmission rates compared to other plastics and it has a good thermal conductivity. It can be molded and can be used with heat welding techniques to bond the jar and cover together. Polypropylene however is a soft material and needs to be mechanically supported. This is usually achieved by using a metal outer tray, which both supports the cell itself and withstands the internal pressure which develops in all VRLA cells. This can actually be a benefit because the outer metal housing can be an excellent thermal radiator which can efficiently remove heat from the cell and radiate it to the surrounding ambient air. A good module tray design will be sufficiently strong to be self supporting and even allow modules to be stacked one atop another.

Effects of Temperature on a Battery Developed in KnowDev

The life of a lead acid battery is predicated on the float voltage being applied at a room temperature of 25°C (77°F). Operating the battery at a lower temperature will result in a loss of capacity. Operating at a higher temperature will result in a loss of useful battery life. For every 10°F above 77°F that the battery is operated at, useful life will be reduced by 50% (approximately).

The power capacity of a lead acid battery will vary with temperature. If the battery is operating in a temperature hostile environment, consult temperature compensation formula's or curves .



Flooded vs. VRLA Considerations Developed in Knowdev

The comparisons below are typical.

	Flooded	VRLA
Specific Gravity	1.215	1.300
Open Cell Voltage	2.06	2.16
Float Voltage	2.17	2.23
Polarization	110mV	70mV
Positive Polarization	50mV	60mV
Negative Polarization	60mV	10mV

Flooded

A flooded battery is one that is constructed with positive and negative plates mounted in a vertical configuration and is filled (flooded) with electrolyte. It is recommended that quarterly maintenance is performed to maintain the integrity of the battery.

VRLA

This battery is constructed with positive and negative plates surrounded with immobilized electrolyte. This allows the battery to be mounted vertically or horizontally (except for very large capacity cells which should only be mounted horizontally).